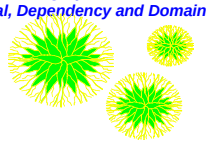
XIX. Class Design

What is Class Design?
Types of Design Classes
Class Specifications and Interfaces
Components, Sub-Systems and Packages
Cohesion and Coupling
Designing Associations
Integrity Constraints
Referential, Dependency and Domain Integrity



Class Design

- Within the context of architectural design, class design:
  - Produces full definitions of classes, associations, algorithms and interfaces of operations;
  - Adds classes that will be useful during implementation;
  - Defines object interactions and object lifetimes in terms of interaction and state diagrams;
  - Optimises data structures and algorithms.

Input/Output for Class Design

- The input is assumed to consist of:
  - Use cases that describe the functional requirements for the new system; also sequence and state/activity diagrams that describe these use cases in more detail;
  - Class diagrams that describe the kinds of things the information system will be managing information about.
- The outputs of class design are:
  - Class packages which describe the overall software architecture of the new system;
  - Supporting sequence, state/activity diagrams that give additional details about the design.

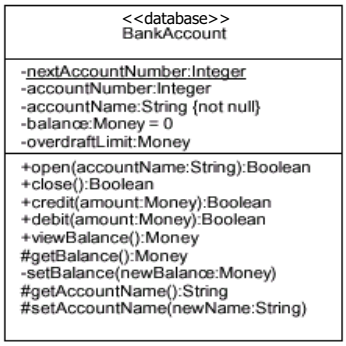
Types of Design Classes

- Most classes defined during requirements analysis represent objects about which information will be stored in the system database.
- During design, we distinguish four types of classes:
  - ***Persistent database classes*** (D), correspond to application classes and describe what will be stored persistently in the system database;
  - ***Entity classes*** (E) represent in-memory, run-time data structures for persistent database classes;
  - ***Boundary classes*** (B) specify interface functions;
  - ***Control classes*** (C) specify business logic functions.

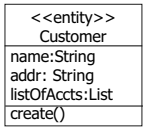
Class Specifications

- Attribute signature
  name: `:´ type-expression `=´ initial-value `{property-string}´
- Operation signature
  Operation name: `(´ parameter-list ´)´ `:´ return-type-expression
- Object Visibility
  - + Public -- The feature is directly accessible by any class;
  - - Private -- The feature may only be used by the class that includes it;
  - # Protected -- The feature maybe used by either the class that includes it or by a subclass of that class;

An Example Database Class

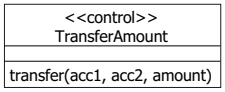


An Example Entity Class



Notes: **`Customer`** objects are created by accessing the **`CustomerDB`** and **`BankAccounts`** part of the database to build a single **`Customer`** object which collects all account information about a customer.

An Example Control Class



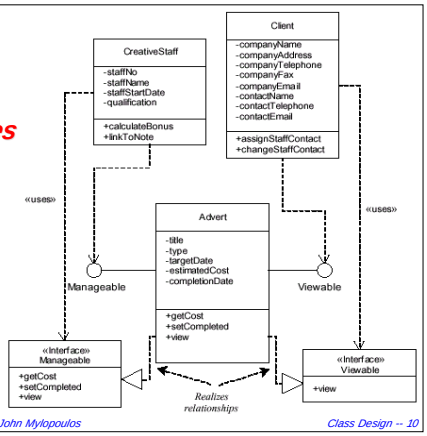
An Example Boundary Class

Look at examples of view and control classes from the previous section.

Class Interfaces

- An ***interface*** is a group of externally visible (public) operations.
- An interface is like a class, but contains no internal structure, has no attributes, no associations and no implementation of its operations.
- The ***realizes*** relationship indicates that the target class supports at least the operations listed in the interface

Class Interfaces



Class Design

- So, a class design consists of a set of packages which contain classes and other packages, and which represent components or sub-systems.
- The grouping of classes into packages may be done from several different points of view:
  - By architectural tier -- Boundary, Control, Entity, Database;
  - By functional relationship -- MVC;
  - By authorship -- who designed what;
  - …

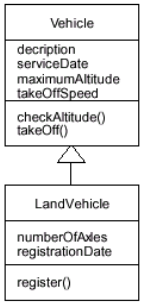
Cohesion and Coupling

Criteria for good sub-system/package design:

- ***Coupling*** measures the degree of interconnectedness between design components/sub-systems/packages.
- The degree of coupling is reflected by the number of links a class has, and by the degree of interaction the class has with other classes.
- Low coupling is preferrable in a design for many good reasons, e.g., easier to understand and modify the design.
- ***Cohesion***, on the other hand, measures the degree to which an element (subsystem, module, or class) contributes to a single purpose.
- Of course, we want a highly cohesive design.

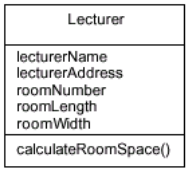
Minimizing Coupling

- Interaction coupling
  - Measures the number of message types an object sends to other objects and the number of parameters passed with these message types;
  - Should be kept to a minimum in order to reduce the possibility of changes rippling through object interfaces;
- Inheritance coupling
  - Degree to which a subclass actually needs the features (attributes or operations) it inherits;
  - A subclass with unnecessary attributes or operations is more complex than it needs to be and instances of the subclass unnecessarily use up more memory.



Maximizing Cohesion

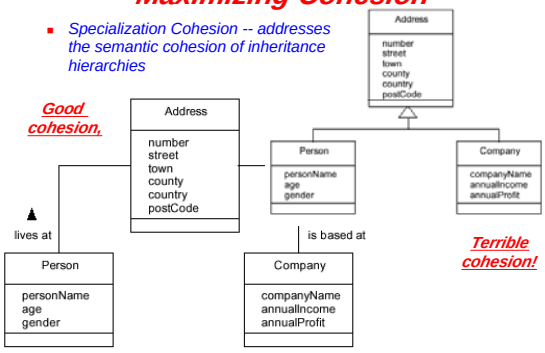
- Operation cohesion
  - Measure the degree to which an operation focuses on a single functional requirement.
  - Good design produces highly cohesive operations, each of which deals with a single functional requirement.
- Class cohesion
  - Degree to which a class is focused on a single requirement.



Good operation cohesion, ...but lousy class cohesion

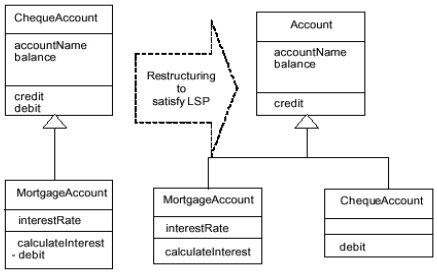
Maximizing Cohesion

- Specialization Cohesion -- addresses the semantic cohesion of inheritance hierarchies



Liskov Substitution Principle

- In class hierarchies, it should be possible to treat a specialized object as if it were a base object.



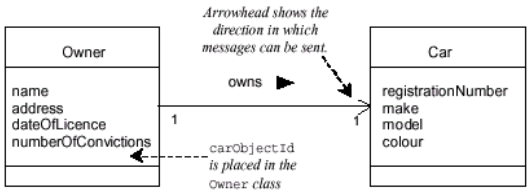
More Design Principles

- ***Clarity*** -- A design should be easy to understand.
- ***Do not over-design*** -- Developers are tempted to produce designs that may not only satisfy current requirements but may also be capable of supporting a wide range of future requirements.
- ***Inheritance hierarchies*** -- Neither too deep nor too shallow!
- ***Keep messages and operations simple***: Limit the numbers of parameters passed in a message; specify operations in no more than one page.
- ***Design volatility*** -- A good design should be stable in response to change in requirements; enforcing encapsulation is a key factor in producing stable systems.
- ***Evaluation by scenario*** -- Can be done with a role play based on use cases, using CRC cards.
- ***Design by delegation***: A complex object should be decomposed into component objects forming a composition or aggregation

Designing Associations

- Each association needs to be analysed to determine whether it should be a ***one-way*** or a ***two-way*** association.
- Depending on multiplicities, we may use collection classes (e.g., lists).
- Need to ask questions about object visibility:
  - does object A need to know object B's object-id?
  - does it need to communicate to third-party objects the object-id?

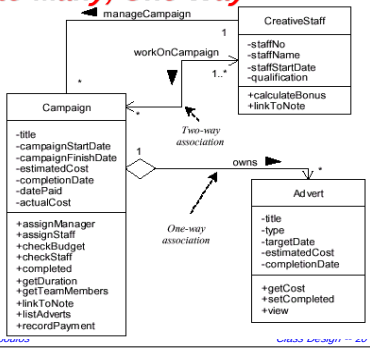
Designing Associations One-to-One, One Way



- **Owner** needs to send messages to **Car** but not vice versa.
- Association may be implemented by placing an attribute to hold the object identifier for the **Car** class in **Owner** objects.

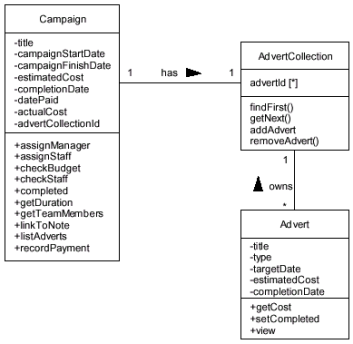
Designing Associations: One-to-Many, One-Way

- The object identifiers could be held in a simple one-dimensional array in the `Campaign` object, but program code would have to be written to manipulate the array.



Collection Classes

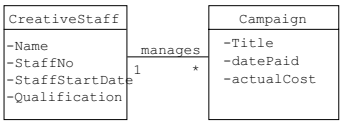
These are classes whose instances are lists, bags, or sets. Collection classes are useful for one-to-many associations



Integrity Constraints

- We'll discuss three types of integrity constraints (...there are many others....)
- ***Referential Integrity*** ensures that an object identifier in an object actually refers to an object that exists.
- ***Dependency Integrity*** ensures that attribute dependencies are maintained, where one attribute may be calculated from other attributes.
- ***Domain Integrity*** ensures that attributes only hold permissible values

Referential Integrity

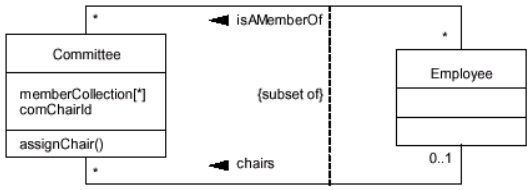


- A `Campaign` must have a `CreativeStaff` instance as its manager.
- What happens if the manager is deleted?
- Referential integrity is maintained by ensuring that the deletion of a `CreativeStaff` object that is a campaign manager ***always*** involves allocating a new campaign manager.

Dependency Constraints: Derived Attibutes

- The value of a derived attribute may be calculated from other attributes.
- For example, the total advertising cost can be calculated by summing the individual advert costs and storing the value in the attribute `totalAdvertCost` in the `Campaign` class or by calculating every time it is required.
- However, whenever the cost of an advert changes, or an advert is either added to or removed from a campaign the `totalAdvertCost` attribute has to be adjusted.
- This can be done by sending message `adjustCost()` to the `Campaign` object.

Constraints Between Associations



- *Enforced by placing a check in* `assignChair()` *to confirm that the* `Employee` *object identifier passed as a parameter is already in the collection class of committee members.*

Designing Operations

- *Determine the best algorithm for the required function.*
- *Factors constraining algorithm design:*
  - *The cost of implementation;*
  - *Performance constraints;*
  - *Requirements for accuracy;*
  - *The capabilities of the chosen platform.*
- *Factors to be considered when choosing among alternative algorithm designs*
  - *The computational complexity of candidate algorithms;*
  - *Ease of implementation and understandability;*
  - *Flexibility;*
  - *Fine-tuning the object model.*